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DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, SECRETARY
BUREAU OF MINES
VAN. H. MANNING, DIRECTOR

CONTROL OF HOOKWORM INFECTION AT THE DEEP GOLD MINES OF THE MOTHER LODE. CALIFORNIA

BY

DR. JAMES G. CUMMING
Director of the Bureau of Communicable Diseases
California State Board of Health

AND

JOSEPH H. WHITE
Sanitary Engineer U. S. Bureau of Mines

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PREFACE.

The Federal Bureau of Mines is authorized by law to make, under the direction of the Secretary of the Interior, investigations with a view to improving conditions that impair the health of miners. Prevention of diseases peculiar to special industries is occupying much attention to-day. In the past possibly too little attention was given to certain baneful effects that were growing up side by side with great industries. Successful combating of industrial diseases is a somewhat complex problem, as it requires a knowledge both of the industry and of the disease.

The Bureau of Mines in its health investigations seeks to cooperate with the existing Federal or State health agencies. In the investigation of hookworm infection in the deep gold mines of the Mother Lode in California, described in this report, three agencies were represented—the California State Board of Health, the Industrial Accident Commission of the State of California, and the Federal Bureau of Mines.

Hookworm infection is a communicable disease; hence the State board of health was desirous of stamping it out. Hookworm infection in mines might be regarded as an industrial injury, so the Industrial Accident Commission of the State of California was desirous of eradicating it. Hookworm infection is prevalent among miners, and as infected miners may spread the infection from the mines of one State to those of another, the Federal Bureau of Mines was interested in preventive measures. The largest share of the expense of the investigation described was borne by the California State Board of Health; most of the field work was done by the Bureau of Mines.

In this investigation Dr. James G. Cumming, director of the State bureau of communicable diseases, represented the California State Board of Health; Edwin Higgins, chief mine inspector, represented the Industrial Accident Commission of the State of California; and Joseph H. White, sanitary engineer, represented the Bureau of Mines.

VAN. H. MANNING, *Director.*

CONTROL OF HOOKWORM INFECTION AT THE DEEP GOLD MINES OF THE MOTHER LODE, CALIFORNIA.

By James G. Cumming and Joseph H. White.

INTRODUCTION.

This report presents the results of an investigation of hookworm infection in the deep gold mines of the Mother Lode, California. In this investigation 1,440 miners of the Mother Lode have been examined for hookworm infection; 444 miners were found to be infected; and 91 miners have taken the treatment and have gotten rid of the infection. Within a short time after this preliminary examination, an industrial strike started, which gradually scattered the miners and made it difficult to institute the treatment of many of those who had been found infected. With the completion, however, of the State survey all these will eventually be identified and treated.

In 1906 Dr. F. F. Sprague, of Jackson, Cal., and formerly of the Philippine Islands, recognized the prevalence of hookworm infection in the gold mines of California. He treated many cases of the infection and brought the prevalence of the disease to the attention of his colleagues. Following closely this pioneer work of Dr. Sprague was that of Dr. E. E. Endicott, health officer of Amador County. In 1911 Dr. Endicott[a] related his experience in a paper before the American Medical Association.

In 1909, Dr. Herbert Gunn, under the auspices of the California State Board of Health, made an investigation to determine the prevalence of the disease among miners.[b] He reported on the blood and stool examinations of groups of men from three large mines in Amador County. The high eosinophilia verified by stool examinations in many of the cases, and the demonstration of larvae in soil from the workings led Dr. Gunn to the following conclusions:

1. Hookworm disease is endemic in certain mines of California.

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[a] Endicott, E. E., My experiences with hookworm infection in the deep gold mines of California: Jour. Am. Med. Assoc., vol. 57, Sept. 30, 1911, pp. 1106–07.

[b] Gunn, H., Hookworm disease in the gold mines of California: Monthly Bull. California State Board of Health, vol. 6, December, 1910, p. 408.

2. From 50 to 80 per cent of those working in these mines are infected.

3. The infection undoubtedly is present in practically all the gold mines of California and in those of Nevada just over the border.

When it was definitely determined by the California State Board of Health to make an investigation, in cooperation with the Industrial Accident Commission of the State of California and the Federal Bureau of Mines, as to the prevalence of hookworm infection among the miners of California, the following procedure was planned: (1) To encourage the superintendents of the various mines to cooperate in the campaign; (2) to diagnose fecal specimens from the miners and determine the percentage of infected miners; (3) to reach an agreement with the superintendents that all infected men must be treated; (4) to make reexaminations of all treated men; (5) to issue "hookworm certificates"; and (6) to eventually reexamine all California miners.

A visit to several of the mines on the Mother Lode made it evident that the mine operators would cooperate most cordially in this campaign; in fact, several superintendents had already considered the advisability of such an undertaking.

ACKNOWLEDGMENTS.

The authors of this paper owe much to the helpful cooperation of the mining operators of the Mother Lode and to all their coworkers in the California State Board of Health; the Industrial Accident Commission of the State of California. and the Federal Bureau of Mines.

DESCRIPTION OF THE MOTHER LODE MINING DISTRICT.

The Mother Lode consists of a series of veins of gold-bearing quartz, situated in Eldorado, Amador, Calaveras, Tuolumne, and Mariposa counties, California. These veins lie in a belt about 6½ miles wide and about 70 miles long that has a general northwesterly direction, and the veins dip about 70° or 80° northeast. The Kennedy Mining & Milling Co. mines the ore through a vertical shaft 4,000 feet deep, and has the deepest gold mine in the United States. Just outside this belt gold was discovered in 1848. At first placer mining in the creeks engaged everyone's attention, but some enterprising miners sought the source of the golden sands, and quartz mining started in the early fifties. The series of rich gold-bearing quartz veins was appropriately named the Mother Lode. This district has yielded many millions of dollars' worth of gold since the pioneering days of '49, and as it yielded $5,788,504 during 1915, an increase of $712,952 over 1914 the district evidently still has a long life before it.

SERIOUSNESS OF HOOKWORM INFECTION IN THE DISTRICT.

Any material prosperity in store for this mining district can not rest on a stable basis if about 40 per cent of the gold miners working underground contract an insidious infection. The authors have no wish to raise imaginary evils. It is frankly admitted that some of the men found infected looked healthy, and if the diagnosis were made by symptomotology, instead of by actual microscopic examination of stools, the presence of the infection would not have been surmised. The infection, although widespread, is at present, in many cases, not far advanced. Unfortunately the obtaining of a personal history of the large number of men found infected was impracticable. Could such histories have been procured it would have been found that the infection produced various effects. The hookworm is an insidious parasite. It does not actually kill, but extends its evil influence in a quiet, cumulative manner, and in different directions. A man can not enjoy normal health while the worms are attached to the inside of his intestines and daily sucking his blood. This fact was illustrated by the testimony as to improved physical condition given by some of the miners after taking the hookworm treatment. It should be remembered that although a miner with hookworm may not be seriously affected himself there is always danger of his spreading the infection if he commits a nuisance in a place favorable to the development of the eggs.

ECONOMIC LOSS DUE TO HOOKWORM.

An attempt was made to determine the economic loss due to hookworm infection in this district. Conclusive evidence was difficult to obtain on account of the many factors involved, chief among these being the lack of permanent mine crews, the miners coming and going, so that records extending over a long period were not available. The time books of the mine enjoying the most permanent labor force were carefully studied for the year 1915. At this mine 80 of the miners and muckers had been in the employ of the company for the entire year. Of these 80 men, 42 were infected and 38 were free from infection. Discounting Sunday absences and absences on account of accidents, it was found that the men infected with hookworm were absent, on an average, nine days more during the year 1915 than the uninfected men. Also it was found that the number of seven-day absences among those with hookworm disease was 57 per cent greater than among those without hookworm. At $3 a day, the annual loss to the miner for nine days' idleness is $27; the loss to the operator can only be approximated. Another point to be considered is this: If the miner stayed away from work for nine days, how many days did he report for duty in a condition unfit to do a good day's work? In a few special cases men that were sick and anaemic were found to be infected, and after treatment immediately showed signs of improvement. Although not directly measurable, the loss caused by hookworm to the miners and mine operators of the Mother Lode has without doubt amounted to many thousands of dollars.

GENERAL CONDITIONS IN THE MINES.

The conditions of the Mother Lode mines and how they compare with conditions in other mining districts of the United States are discussed in some detail on pages 9 to 35, but in general it may be said that the sanitary conditions are believed to be above the average. A number of improvements indicative of a progressive and liberal-minded policy can be found in the mines of the Mother Lode. Among these might be mentioned the presence of miners' wash and change houses, underground toilet accommodations, garbage cans underground for food remnants, water for washing the hands before eating and benches for the miners to sit on while eating, bubbling drinking-water fountains underground, filtered drinking water, cooled during the summer, water drills and sprinkling devices in the mines, regulations against firing shots between shifts, respirators supplied to miners free of charge, dust-settling devices on the grinders in the mills, improved drainage conditions in the mines, Sunday a holiday, and vacations with pay granted to the men. It must be understood that the equipment and the privileges named are not found at all of the mines, the list representing the sum total rather than the universal condition. One of the improvements may be found at one mine, another at a second mine, and so on. The presence of these improvements within the district makes their lack in several of the mines more evident. If one mine can install these improvements their practicability has been proved; why not all the mines?

HOOKWORM INFECTION IN THE MINES.

By Joseph H. White.

MICROSCOPIC EXAMINATIONS.

Fecal specimens from 1,096 of the workingmen from eight Mother Lode mines were microscopically examined for hookworm eggs. The results are shown in Table 1. These data, with other information collected about the 1,096 workingmen, furnish the basis of this report.

Table 1.—*Results of examining fecal specimens of 1,096 workmen employed at eight mines in the Mother Lode district.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.	Total.
Total number of men examined	195	292	199	70	56	47	138	99	1,096
Number found infected	66	47	107	25	13	8	44	27	337
Percentage infected	34	16	54	36	23	17	32	27	31
Underground workers:									
Number examined	158	292	171	57	56	29	121	85	969
Number found infected	95	47	114	22	13	6	40	26	363
Percentage infected	60	16	67	39	23	21	33	31	38
Surface workers:									
Number examined	37	......	28	13	......	18	27	14	137
Number found infected	3	......	1	3	......	2	4	1	14
Percentage infected	8	......	4	23	......	11	15	7	10

This table shows that of the 1,096 men examined 337, or 31 per cent, were infected with hookworms. In this table the mine employees are considered as in two classes, underground workers and surface men. It will be noted that of the 969 underground workers examined 363, or 38 per cent, were infected; whereas of the 137 surface men examined only 14 men, or 10 per cent, were infected; moreover, nearly all of the 14 infected men had formerly worked underground.

NONINFECTION AMONG SURFACE WORKERS.

The results shown in Table 1 indicate that hookworm infection is closely related to the mining industry, for if only 10 per cent of the *surface* workers at mines were infected, it is reasonable to expect that in this particular district few workers not miners are infected. It is somewhat surprising that in a mining district where 337 miners were daily evacuating hookworm eggs the infection had not become widespread among men engaged in other occupations. This absence of infection among the nonmining inhabitants can be explained in two ways. First, the number of unprotected, insanitary privies in the towns where the miners live is not large, and the privies which are present have earth vaults or are placed over a stream bed, so that the infectious bowel discharges are not spread about areas traversed by men. Many of the houses have sewers which empty into the creeks. The second protective feature is the long dry spell in this district, which would tend to destroy and make nonviable any hookworm eggs that were voided indiscriminately. The total annual rainfall for this district during 1915 was 27.69 inches and the five months of June, July, August, September, and October were absolutely dry, no precipitation whatever being recorded.

INFECTION AMONG MINERS.

The fact that such a high rate of infection prevails among miners in the Mother Lode mines would seem to prove offhand that the infection is contracted in these mines, but the labor is of a transient type; miners are constantly coming and going. The average duration of employment of the 969 underground men examined was 6½ years. Hookworms will live inside of a man for more than 10 years; therefore the fact that miners in this district were found to be infected does not necessarily prove that the infection was contracted in these Mother Lode mines. The miners may have been infected before they came to these mines.

The evidence, however, goes to show that the mines of the Mother Lode are infected and that all the infection is not imported. This important point is brought out by the following facts:

1. The low percentage of infection among surface employees as compared to the high percentage of infected underground workers indicates indirectly that the mines are infected, because if the infection was all imported the proportion of infected men on the surface would probably be larger.

2. In one mine examined, 75 of the underground men were found to be infected and 75 were not. It was found that the duration of previous mining experience of the infected men was about the same as that of the noninfected men, averaging 5½ years for the infected men and 5 years for the other men. If the infection was imported, that is, if it depended upon their previous experience rather than their present work, it would appear that the infected men would have had a much greater previous experience than the noninfected men.

3. The date of employment of every man examined was recorded, and the duration of his service at the present mine up to the date of his examination was figured. It was found that the average duration of employment of the infected men was 12 years and that of the noninfected men was 3 years. As the noninfected men had not worked

in these mines so long as the infected men had, it would appear that there is a relation between the mines and the source of infection.

4. At one mine it was found that 17 of the 77 infected men had never worked in mines elsewhere, and that 4 men were infected who had previously taken the hookworm treatment and had not worked in any other mine since they had taken the treatment. This indicates that this particular mine is infected and the similarity of conditions between this mine and other Mother Lode mines is presumptive proof that the mines are infected.

SOURCE OF INFECTION NOT KNOWN.

Hookworm could have been introduced into these mines from any one or all of several different countries. The infection may have been imported by miners from Cornwall, England, as there are many Cornishmen in the mines of the Mother Lode and it has been proved that Cornwall mines were once infected, or it may have been introduced by Italians, Spaniards, or Mexicans, as many of the miners are of such extraction, and the Rockefeller Hookworm Commission has found that all of these countries are infected. It is not important to know where the infection came from, although to determine the species of hookworm would be of assistance in deducing their origin. The important fact to be faced is that hookworm infection is present in these mines and ought to be eradicated.

PRESENT UNDERGROUND TOILET FACILITIES.

There are many contributory factors to the spread of hookworm infection, but all of them operate only after the infectious eggs have been set at large by the careless disposition of human excrement. The source of all hookworm infection is in the discharges from the bowels. Information in regard to the underground toilet accommodations at the mines examined is shown in Table 2 following.

TABLE 2.—*Data in regard to underground toilet facilities at mines examined.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Toilet accommodations, underground	Yes	Yes	Yes	No	No	Yes	Yes	Yes.
Men supposed to go to surface	No	No	No	No	Yes	No	No	No.
Men supposed to use pump sump	No	No	No	Yes	No	No	No	No.
Portable cans placed in commodes	Yes	Yes	Yes	No	No	Yes	Yes	Yes.
Number of years installed	5	¼	½			2	1½	1.
Number of times per week cleaned	2	2	7			1	1	1.
Date of inspection of mine (1916)	Feb. 17, 19, 21, 23, 28.	Mar. 20, 21, 22.	Apr. 19	Mar. 29 June 26	May 9	May 5	May 13	May 22

Six of the eight mines examined had toilet cans, which were supposed to be used by the men and which were brought to the surface and emptied at regular intervals. At one of the mines the men were supposed to go to the surface when necessary; at another mine the men defecated in an inconvenient and insanitary way into the pump sump. With the exception of one mine the introduction of toilet cans is of comparatively recent origin, and the delay in introducing their use has doubtless contributed largely to the spread of hookworm infection.

IMPROVEMENTS IN UNDERGROUND TOILET FACILITIES RECOMMENDED.

Although the basic features of the present underground toilet systems are correct in that the infective material is collected and removed from the mine, certain details should be improved upon.[a] Not only should the toilets be installed, but their use should be strictly enforced, and to require this the toilets must be maintained in a usable condition. They should be emptied at least three times a week or, preferably, every night, as is done in one mine. The cans that were emptied once a week had an odor so vile that it would nauseate a person to use them. If the can is situated in a cross-cut that makes water, galvanized iron sheets should be placed over the can like a shed roof, to prevent the seat becoming wet from the mine drippings.

It is believed that if the cans are one-quarter filled with water, with some disinfectant added at the time they are placed in the mines, conditions would be better than if a powdered disinfectant is used. Under any circumstances the work of cleaning these cans is a disagreeable task, but if the contents are maintained in a liquid state by the addition of water the deposits will not adhere to the sides and corners of the can, but will readily pour out, and the churning, foul odors, and ineffective cleaning, incident to the emptying of the solid deposits, will be avoided. If water is to be added to the cans a water-tight cover and one that is readily removable must be provided for the cans, so that the material will not splash out while the cans are being conveyed to the surface.

Some of the mine superintendents complained that the toilets were abused and defiled by some of the miners, the trouble being caused by the men standing instead of sitting upon the seats. Two reasons prompt the men to squat upon the seats—fear of contracting vermin or disease or because the seat is wet or defiled. These reasons are rational ones, and a properly designed toilet will do much toward correcting the abuses.

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[a] For discussion of sanitation in mines see White, Joseph, Underground latrines for mines: Tech. Paper 132, Bureau of Mines, 1916, 23 pp.

The design of an underground toilet in which careful attention has been given to details is shown in figures 1 and 2. Note the sanitary seat open back and front.

Plate I shows three views of an underground toilet invented and on sale by a mine-supply house in California. An ingenious feature is the way in which the disinfectant is automatically thrown into the can after each use.

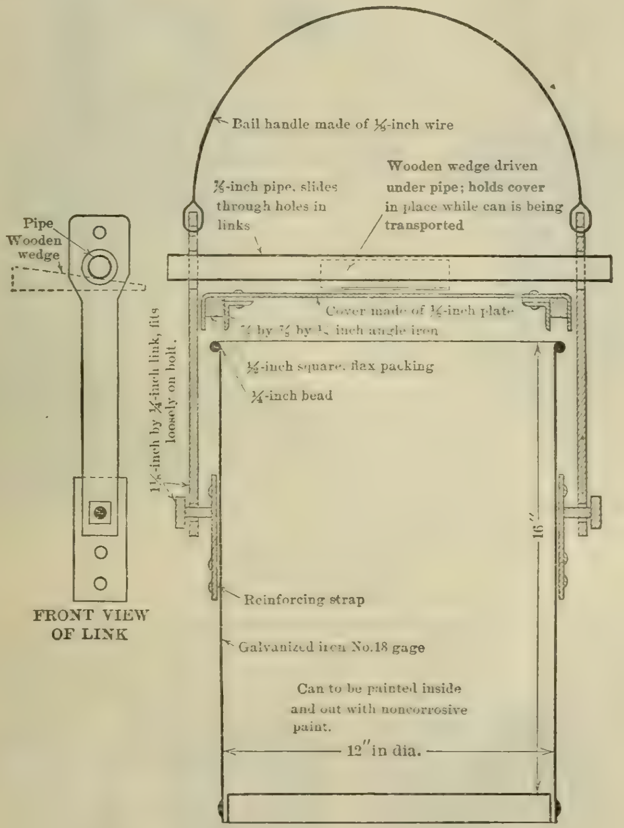
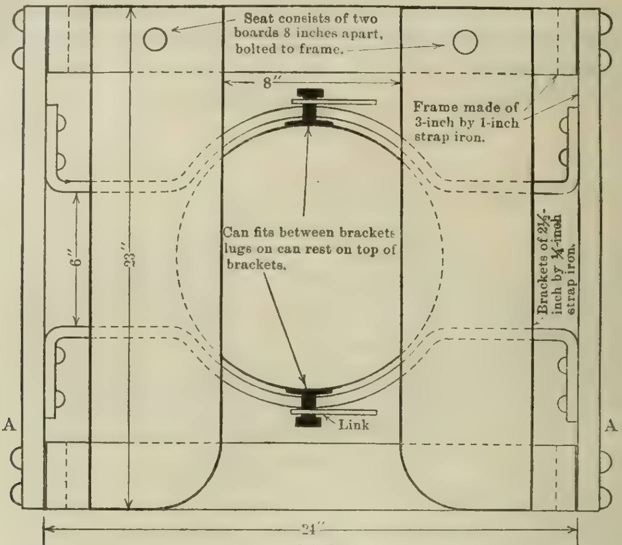

Bail handle made of ⅜-inch wire
¾-inch pipe, slides through holes in links
Wooden wedge driven under pipe; holds cover in place while can is being transported
Pipe
Wooden wedge
Cover made of ⅛-inch plate
¾ by ⅞ by ⅛ inch angle iron
½-inch square, flax packing
¼-inch bead
1⅛-inch by ¼-inch link, fits loosely on bolt.
16″
Reinforcing strap
Galvanized iron No. 18 gage
Can to be painted inside and out with noncorrosive paint.
12″ in dia.
FRONT VIEW OF LINK

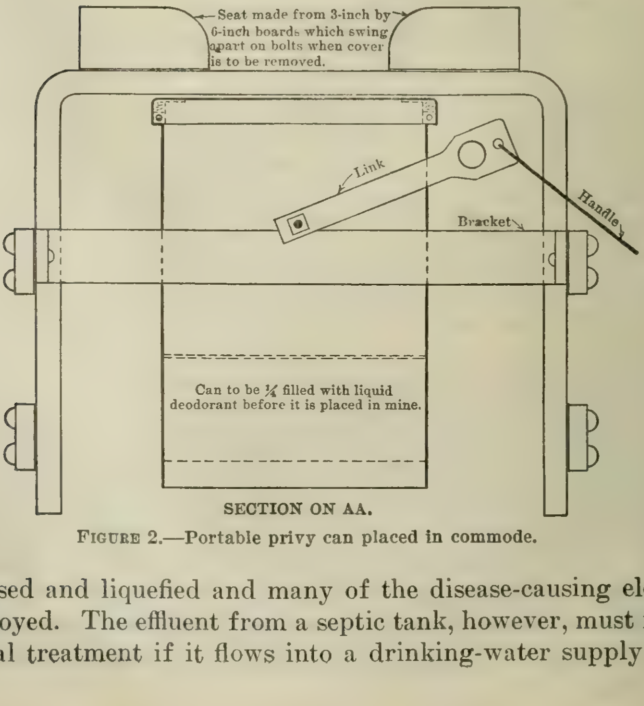
FIGURE 1.—Portable privy can for use in mines.

EMPTYING CANS AT SURFACE.

The method in which the contents of the cans should be disposed of when they are brought to the surface depends largely on local conditions at and around the mines. The material must be so disposed of that it will not pollute a drinking-water supply, so that it will not be disseminated by flies, and so that no nuisance shall be created. In some places it would be satisfactory to empty the cans into a covered leaching pit into which lime is sprinkled at regular intervals. This pit should be so situated or protected as to prevent pollution of the water supply. At some mines the material could be passed through a septic tank of approved design. In a successfully operated septic tank the solid matter in sewage is decomposed and liquefied and many of the disease-causing elements are destroyed. The effluent from a septic tank, however, must receive additional treatment if it flows into a drinking-water supply. If a

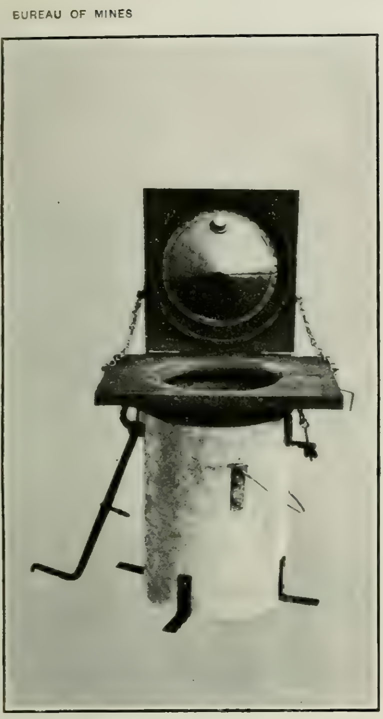

Seat consists of two boards 8 inches apart, bolted to frame.
8″
Frame made of 3-inch by 1-inch strap iron.
Can fits between brackets lugs on can rest on top of brackets.
Brackets of 2½-inch by ¼-inch strap iron.
6″
23″
A
A
Link
24″

PLAN

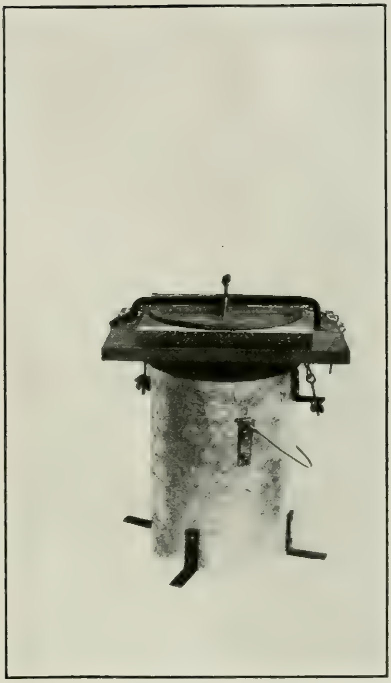

Seat made from 3-inch by 6-inch boards which swing apart on bolts when cover is to be removed.
Link
Handle
Bracket
Can to be ¼ filled with liquid deodorant before it is placed in mine.

SECTION ON AA.

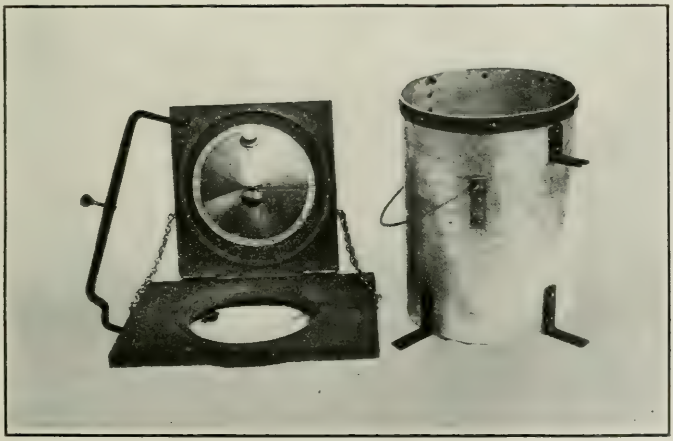
FIGURE 2.—Portable privy can placed in commode.



A. PRIVY CAN, READY FOR USE.



B. PRIVY CAN, CLOSED FOR REMOVAL.



C. PRIVY CAN, WITH COVER REMOVED FOR CLEANING.

septic tank is used, strong disinfectants should not be added to the cans, as this would kill the bacteria upon which the septic tank depends for its liquefying function.

SURFACE TOILETS.

It is believed that if a modern, sanitary, water-flush closet were installed on the surface near the change house many of the miners would use this instead of waiting until they went underground. The time of bowel movement can be regulated to a large extent. One of the recommendations made to the miners is that they use the underground toilets only when necessary. Most of the present surface closets are foul smelling, inadequate, and inconveniently located.

An inexpensive water-flush closet is shown in figure 3. The price of a closet similar to the one shown but with four sections instead of five is about $175 f. o. b. San Francisco, Cal. It is built in sections and any number of seats can be ordered. It flushes automatically at any interval desired, and it does not get out of order easily. The effluent from this can be conducted to the same pit or disposal tank at which the mine cans are emptied.

DRINKING WATER IN THE MINES.

Drinking water has little to do with the spread of hookworm, but an abundant supply of pure wholesome drinking water is so fundamentally necessary, particularly in mines, where working in such warm temperatures creates an abnormal thirst, that a few suggestions are offered.

The drinking water chiefly in use over the district examined is snow water, conveyed there from the mountains in an open ditch about 40 miles long. Two samples of this water were taken on February 28, 1916, one sample being drawn from the tap at the collar of one of the mines and the second from a tap in a drug store in Jackson, Cal. These samples were analyzed in the California State Board of Health laboratories and found to be heavily infected with intestinal bacteria and were pronounced unsafe for drinking purposes unless purified in some way. The samples were collected after a heavy rain, and, although, no doubt, they showed more bacteria than the water contains normally, it is important that a drinking-water supply be judged by its worst, not its best, conditions. The sanitary chain is no stronger than its weakest link.

All of the mines except one either clarified the water by passing it through small filters attached to the water pipe or depended on natural filtration through the ground. No test was made of the efficiency of these filtration methods. One mine received its drinking-water supply from a spring located near by. During the summer all of the mines add ice to the drinking water, and one mine operates a refrigerating plant for this purpose. One mine, not a deep one, has bubbling fountains at the mine collar and at the stations underground.

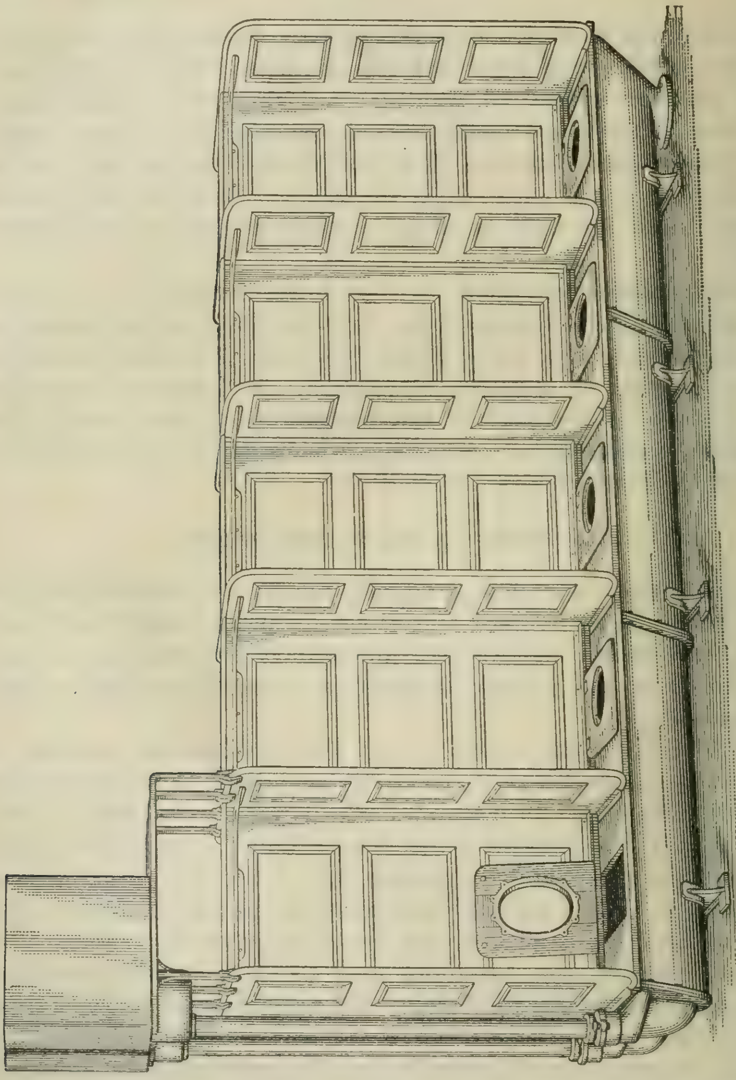


FIGURE 3.—Water-flush closet for surface toilet at mines. (Illustration furnished by Standard Sanitary Mfg. Co., Pittsburgh, Pa.)

In seven of the eight mines examined the drinking water was carried into the mines in kegs, varying in capacity from 3 to 5 gallons. These kegs were placed at the underground stations and at points in crosscuts or drifts convenient to the workingmen. Fresh water was taken into the mines several times a day.

The manner in which the men drink from these kegs is seriously unhygienic and should be corrected at once. In some of the kegs a small iron nipple is screwed into the end, and the men's lips come in contact with this when they drink. In some of the mines there is merely a hole in the side of the keg and the men place their lips to this hole and tip the keg. This procedure not only permits the lips to come in contact with the keg, but it also permits the water to circulate through the drinker's mouth and back into the keg. The writer examined the death certificates of 291 miners of Amador County. On 96 of these, or 33 per cent, tuberculosis was assigned by the attending physicians as the cause of death. It is well known that tuberculosis is a lingering disease—the average age of the 96 men deceased from tuberculosis was 49 years—and that tubercular victims often continue to work when the disease is in its advanced infectious stages. The hole in the keg is the common drinking place for miners suffering from tuberculosis, syphilis, or other diseases, and miners in good health. Another objectionable feature is that men chewing tobacco may drink from the hole. A simple and inexpensive way of preventing the lips coming in contact with the keg is shown in figures 4 and 5.

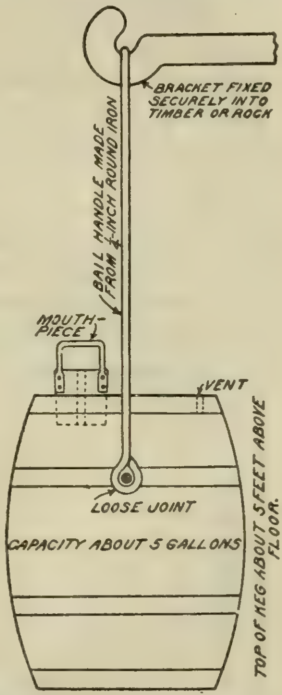

BRACKET FIXED SECURELY INTO TIMBER OR ROCK
BAIL HANDLE MADE FROM ½-INCH ROUND IRON
MOUTH-PIECE
VENT
LOOSE JOINT
CAPACITY ABOUT 5 GALLONS
TOP OF KEG ABOUT 5 FEET ABOVE FLOOR.

FIGURE 4.—Drinking-water keg for use in mines.

The water kegs should be steamed out thoroughly every night. At some mines the superintendent's orders regarding care of water kegs are not always carried out. At one mine a sample of water was taken from the tap at the collar where the kegs are filled and a sample was drawn from one of the kegs in the mine. The keg water sample contained more bacteria than the sample drawn from the tap.

EARLIER INSANITARY CONDITIONS.

Before the introduction of toilet cans into the mines the workmen defecated either in filled stopes or in abandoned crosscuts, in drainage sumps, or in mine cars or ore bins. The infected feces in the course of time became spread throughout the mine, either being tracked about on the miners' shoes or spread by mine cars or possibly by rats. The writer believes, however, that the mine water was an important disseminating agent.

VIABILITY OF HOOKWORM EGGS.

It has been stated that hookworm eggs will remain infectious for only about a year after they have been evacuated from the intestines. This may be the case when the eggs are exposed to the variable climatic conditions on the surface; but hookworm eggs appear to remain infectious for a longer period than one year when they are deposited in the mines, where temperature conditions remain fairly uniform year in and year out. One of the mines, at which 60 per cent of the underground men are infected with hookworm, installed dry closets about five years ago, and their use has been enforced to some extent. In spite of these sanitary precautions, eight men were found infected who never worked in mines elsewhere and entered this mine after the installation of the closets. A few men who were treated for hookworm since the installation of the closets were found to be reinfected. This leads one to believe—although it is doubtful—that possibly some of the infection results from the survival of infectious places created five years ago in the mine before the cans were installed.

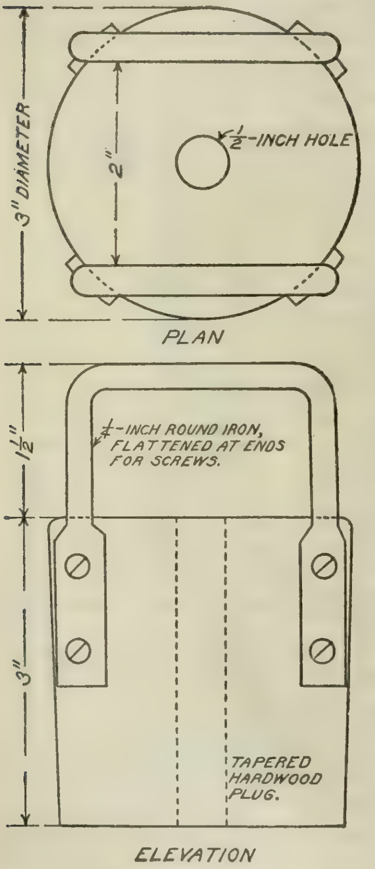


FIGURE 5.—Sanitary mouthpiece for drinking-water keg.

WAYS IN WHICH HOOKWORM IS CONTRACTED AND DISSEMINATED.

Many kinds of germs can gain entrance to the body through the mouth or through the skin after it has been cut or broken. In addition to these two ways, hookworm larvæ can bore through the intact skin at whatever place infected dirt happens to come in contact with the body. A miner can not do his work without getting dirt on his hands and clothing; therefore his safety lies in keeping the dirt of the mine as noninfectious as possible. With a mine once infected, the means whereby the miner becomes infected are obvious. They are discussed in detail in the following pages.

MINER'S SHOES.

In hookworm-infected countries where the inhabitants go without shoes, the logical place for hookworm larvæ to gain entrance to the body is through the feet. Hookworm larvæ might easily work their way through a fairly good pair of shoes, but the infection would be light. When a mine is known to be infected, a miner should take unusual care to keep his shoes in good repair. At the change house of one infected mine 107 pairs of miners' shoes were examined and 43 pairs, or 40 per cent, were found to be broken or worn so as to permit hookworm infection. The miner's shoes are a large item of expense. Mine shoes cost about $5 a pair, and in some mines they last only four months. Considering the repairing necessary, the average miner will spend about $20 per year on shoes. The companies could save the miner some expense if shoes were kept in the storehouse and sold to the miners at cost.

MINE LADDERS.

Some of the underground workmen may contract hookworm from the mine ladders. The infectious dirt gets stuck on the shoes and it is scraped off the shoes onto the rungs of the ladders, whence it rubs into the skin of the hands. Figures are given on page 31 which show that bosses and repair men, who move about the mines extensively and frequently climb ladders, are more apt to become infected than men who work steadily in the stopes.

RATS.

Rats possibly spread the infectious material. In six of the eight mines examined rats were observed. At one mine three rats were trapped and their intestines examined for hookworms and then their feces examined for hookworm eggs. None was found. Although hookworms are not known to occur in rats, they may, however, spread the hookworm eggs mechanically by their legs and bodies. The workman who empties the toilet cans at one of the mines stated that rats often get into the toilet cans.

At some of the mines large numbers of rats are present and are very tame, being fed and "petted" by the miners. At lunch time, when the miners gather at the station to eat, the rats likewise assemble, and the miners throw them scraps of food. Some of the miners believe that the rats warn them of unseen dangers, and say that the rats can tell by instinct when the roof is unsafe. The high proportion of accidents due to falls of rock makes one doubt the truth of this statement, and it is doubtful whether rat-infested mines have less accidents than mines without rats. At any rate, these disease-carrying pests should be eliminated from mines regardless of any superstitions miners may have regarding their usefulness.

UNDERGROUND EATING STATIONS.

Hookworm larvæ may gain entrance to the body through the mouth, and the conditions under which the miners eat make possible a source of infection. Facts regarding this practice are shown in Table 3.

TABLE 3.—*Data showing toilet facilities available during underground meals.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Do miners eat underground	Yes	Yes	Yes	Yes	No	No	Yes	Yes.
Facilities present for washing hands	No	No	No	No	Yes	Yes	No	No.
Benches present at underground stations	No	Yes	No	No	No	No	No	No.
Garbage cans present at underground stations	No	No	Yes	No	No	No	No	No.

Conveniences for eating in the mines are, in most cases, unsatisfactory. Shortly before dinner time the dinner buckets are sent down from the surface. The miners assemble at the stations and sit on old timbers or on the floor, their buckets being held or placed between their legs. It is said that sometimes food is spilled by buckets getting tipped over. At some mines fresh drinking water is sent down at meal times, but tea or coffee is the favorite beverage. Some of the miners wash their hands in water poured from the drinking-water keg; others are said to wash their hands in the drainage ditch; many eat unwashed. Apparently the only reason for perpetuating these conditions is that such has been the practice in mines for years past and so it goes on. This statement applies to most mines in the United States. Mining, at its best, is not a pleasant occupation, and has many disagreeable features that are difficult to correct, but this is not the case with eating underground. Among its numerous other functions the underground mine station at certain periods of the day becomes the miners' dining room; why not respect it as such? Water for washing the hands should be provided; benches, allowing about 2½ feet of seating space per man, should be placed in the stations for the men to sit on while eating; garbage cans should be provided for food remnants and their use enforced; the station should be well lighted and kept as clean and as free from unnecessary débris as possible.

MINERS' WASH AND CHANGE HOUSES.

All of the mines on the Mother Lode have had wash and change houses for a number of years, although these are not required by law, and no charge is exacted from the men for their use. There are many mining districts in the United States where this improvement is just being introduced, and many mines are still without them.

Information about the wash and change houses in the Mother Lode district is shown in Table 4.

TABLE 4.—*Information on wash and change houses at mines examined.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Is there a wash and change house?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Has it a concrete floor?	No.	No.	No.	No.	Yes.	No.	No.	No.
Is it kept neat and clean?	Yes.	Yes.	No.	No.	No.	Yes.	No.	No.
Number of showers present	13	6	10	......	1	......	2	2
Are facilities for washing hands satisfactory?	No.	No.	No.	No.	No.	No.	No.	No.
Are common wash basins in use?	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
Are facilities for boiling underground working clothes provided?	No.	No.	No.	No.	No.	No.	No.	No.
Are surface toilets satisfactory?	No.	No.	No.	No.	No.	No.	No.	No.

Many of these houses have been in use for some years and do not possess the up-to-date conveniences of the more modern wash and change houses. Improvements have been developed in the construction of washhouses as in every other branch of mining. It would be unreasonable to expect these washhouses to be abandoned, but certain inexpensive improvements should be made on them. There is no excuse for the objectionable condition in which some of the washhouses are found. When a new floor is required the wooden floor should be replaced with a well-drained concrete floor, and it would be well to have concrete extend up the sides for a few feet. More showers should be installed at most of the washhouses. The facilities for washing the hands and face should be improved. At present metal washbasins are used, and some miners bend over the trough and wash only the upper part of the body. This practice exists among only certain classes of miners. Provision should be made for the men to wash their hands and face in flowing water, and the common washbasins should be discarded.

FACILITIES FOR WASHING THE MINERS' WORKING CLOTHES.

Facilities should be provided in all washhouses so that the miners could boil their underground working clothes. It has been claimed, and with some truth, that the miners' underclothes are washed less frequently since the introduction of washhouses than they were previously, as when the miner wore his " shift " clothes home his family would see that they were washed, but when the miner leaves his working clothes at the mine this supervision is missing. Towels should be boiled often, at least three times a week. If a number of galvanized iron tanks about 20 inches in diameter and 24 inches deep were installed and connected with hot-water or possibly live-steam lines the condition in which the working clothes and towels were kept would no doubt be much improved.

MINE-DRAINAGE SYSTEM.

It is believed that mine drainage has been and is an important factor in the spread of hookworm infection, as the mine water causes the humidity that appears to be essential to the development of hookworm eggs, and furnishes a medium for conveying the eggs all over the mine. If the mine made no water the infectious material for the most part would remain where the stools were evacuated, and few miners would come in contact with it. If, however, an infected miner commits a nuisance in a wet stope the mine water filtering through the stope picks up the hookworm eggs and conveys them to the traversed levels, or if the miner commits a nuisance in an abandoned crosscut which makes water the infectious eggs may be reconveyed into the active parts of the mine.

In an upper abandoned level of one of the mines examined a stool was found partly submerged in a drainage ditch. A specimen of this stool was microscopically examined and it was found to be infected with hookworm eggs. Although eggs that are under water will not develop, the eggs and the larvæ are doubtless scattered around by the water. This furnishes a concrete example of how hookworm-infected material may be spread in a mine.

It is not the quantity so much as the way in which the mine water is taken care of that is important. In mine B, which makes 125,000 gallons daily, only 16 per cent of the men were infected. Possibly more attention was given to the drainage system in this mine than in any of the other mines examined. An effort was made to intercept the water at each level and not permit it to drain on through the stopes. The intercepted water was conveyed in well-maintained ditches to sumps at the stations. On some of the levels the water was carried in small wooden boxes or flumes, and these helped greatly in keeping the passageway and footboards dry. The foreman at this mine said it pays to keep the mine water out of the stopes, because, besides making the stopes mucky, disagreeable, and dangerous to work in, the water saturated the "gouge" formations and caused the ground to swell and thereby increased the cost of timbering. The mine water had to be removed anyway, and the expense of pumping was less if it was intercepted on the upper rather than the lower levels.

In mine C, which made 190,000 gallons of water, 67 per cent of the men were infected. The mine water was not carefully handled, the mine ditches not being well maintained, and in several places the footboards were flooded and mucky.

CHARACTER OF MINE WATER IMPORTANT.

It is said that hookworm larvæ will not live in mine water which contains 2 per cent of salt[a] or if the mine water is 0.2 per cent acid or alkaline.

Practical confirmation of this has been found in the conditions which exist at the Levant mine, near St. Just in Cornwall. Tin, copper, and arsenic are extracted from this mine. Although it is one of the very deep mines of Cornwall, it is also one of the most healthful. In this mine the eggs of many of the intestinal parasites that infest men were found, but in the fecal matter lying about no eggs of hookworm were detected. Their absence was attributed to the fact that as the mine is under the sea the sea water filters through the strata into the mine.

In some of the inland coal mines of France, especially those between Anzin and Denain, Manouvriez[b] found that the waters percolating into the mines were saline, and that they probably came from subterranean caverns, remnants of ancient seas or of salt-water lakes lying above the carboniferous strata. Analyses showed that these waters contain 0.7 to 2 per cent of common salt. It is interesting to observe that in those pits in which the water contains the higher percentage of salt there are no cases of hookworm infection among the miners, although the malady is present in other pits not so fortunately watered.

The water in the mines of the Mother Lode is alkaline. A sample from one of the lower levels of one of the deepest mines was analyzed and it was found to be only 0.043 per cent alkaline, whereas to be an effective sterilizing agent it should be about 0.2 per cent alkaline.

A specimen of feces found partly submerged in a drainage ditch of one of the mines, was collected, care being taken to select the specimen from the submerged part of the stool. The specimen was found to be heavily infected with hookworm eggs.

Specimens of the excreta from 204 miners who work in one of the copper mines in the northern part of the State of California were examined. The water in this mine is highly acid, analyzing 0.01 per cent acid. Only 3 per cent of the men examined were infected, and the possibility that these men brought the infection with them, rather than contracting it at the mine in question, must be considered.

CONGESTION IN THE MINES.

One of the reasons why hookworm infection became widespread in the mines of the Mother Lode, is due perhaps to the steep dip of the ore deposit, averaging as it does about 70° to 80°. As the levels are developed one below the other, the mine water which drains through the old upper infected levels leaks down into the new workings. It is as if in a 20-story building, the tenants on the top floor permitted their waste water to leak through upon the residents on the nineteenth floor, and then those on the eighteenth floor, after receiving the waste from the nineteenth and twentieth, would add theirs to it and pass it on to the tenants on the seventeenth, and so on. If toilet cans had been installed in the mines of the Mother Lode 20 years ago, rather than 2 years ago, hookworm infection might never have gotten a foothold.

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[a] Manouvriez, A., Prophylaxis of ankylostomiasis: Brit. Med. Jour., vol. 161, pt. 2, Nov. 25, 1905, p. 1418.

[b] Manouvriez, A., article cited.

In most of the coal mines in the United States to-day there is absolutely no toilet provision whatever and the miners commit nuisances all over the mine. The coal deposits, for the most part, lay in a horizontal strata, and their development spreads over great areas rather than sinking to great depths. This perhaps helps to account for the fact that coal mines are not heavily infected with hookworm. The toilet accommodations in coal mines are, as a general rule, worse than in the metal mines.

The approximate slope of the shaft, the number of mine levels developed, number of active working levels, depth of lowest level along the slope, approximate amount of water removed daily, approximate number employed underground, and percentage of underground men found infected are shown in Table 5.

TABLE 5.—*Data on slope, development, drainage, and proportion of underground workers infected with hookworm in the mines examined.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Approximate slope of shaft, degrees	60	90	70	70	50	50	60	50
Number of mine levels developed	35	....	16	24	6	5	16	12
Number of active working levels	5	13	6	5	4	3	6	4
Depth of lowest level (along slope), ft.	4,200	3,750	2,850	3,200	1,400	700	2,400	2,350
Approximate water removed daily, gallons	40,000	125,000	190,000	20,000	145,000	30,000	....	100,000
Approximate number of men employed underground	135	270	260	60	55	30	125	100
Percentage of underground men found infected	60	16	67	39	23	21	33	31

TEMPERATURE OF THE MINES.

A number of temperature and humidity readings were taken in all of the mines. In selecting the places for the readings an effort was made to get a fair average temperature of the active part of the mines. Some temperature readings were taken in abandoned levels, but these were not included in computing averages. Information about temperature and relative humidity is shown in Table 6:

TABLE 6.—*Temperature and humidity of mines examined, and number of men infected with hookworm.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Number of temperature and humidity readings taken	32	31	24	18	11	21	32	16
Levels (depth in feet) between which readings were taken	3,600 and 4,200	2,000 and 3,750	1,800 and 2,850	700 and 3,200	900 and 1,400	500 and 700	1,200 and 2,400	1,650 and 2,350
Highest temperature observed, °F	88	84	83	79	70¾	68	79½	77
Lowest temperature observed, °F	80	67	70	61½	62	58	72	67½
Average temperature, °F	83	78	75	73	68	63	76	72
Highest relative humidity	100	100	100	100	100	100	100	100
Lowest relative humidity	92	91	95	94	93	95	96	92
Average relative humidity	97	97	99	97	98	99	99	97
Depth of lowest working level along slope	4,200	3,750	2,850	3,200	1,400	700	2,400	2,350
Percentage of underground men infected	60	16	67	39	23	21	33	31

This table shows that the highest temperature found in any of the mines was 88° F. and the lowest was 58° F. Mine A had the highest average temperature, 83° F., and mine F had the lowest average temperature, 63° F.

Thomas Oliver, in an article entitled "Miners' Worm Disease," in the April, 1905, issue of the Journal of State Medicine, states that temperatures between 68° and 90° F., with a certain degree of moisture, are favorable circumstances for the development of hookworm eggs into larvæ. All of the mines examined on the Mother Lode, except one, have an average temperature between these limits. The extent of the hookworm infection, however, does not vary with the temperature, as mine B, which is second highest in temperature, is the least infected of all the mines. The author believes that with the infection once introduced, it is not so much the warmth of the mines as the uniform temperature accompanied by high humidity that makes the deep mines of the Mother Lode favorable for the development of hookworm infection. Table 6 shows an interesting relationship between depth and temperature.

With the exception of mine A all of the mines were connected to at least two shafts so that natural ventilation existed. Mine A is hastily pushing to completion its connection with a second opening.

Besides the depth and number of openings, a factor influencing the temperature is the amount of timber in the mine. Some of the hottest temperatures were found to be near stopes which had been filled with old mine timbers. Most of the mine superintendents now believe that the practice of filling stopes with old timber is false economy. Besides increasing the temperature and thereby reducing the efficiency of the workmen, the fire hazard of the mine is increased. In most of the mines the old timber is now hauled to the surface and burned under the boilers.

RELATIVE HUMIDITY.

The high relative humidities of the mines examined, shown in Table 6, help to make these mines fertile breeding places for hookworm. The average temperature in the mines may be affected somewhat by the temperature outside, but the relative humidity of the mine air appears to have little relationship with the relative humidity of the intake air. Temperature and humidity readings were taken at the surface at mines D, F, and H on the day of their examination. The difference in humidities between the surface and underground is far more striking than the difference in temperatures, as shown in Table 7.

TABLE 7.—*Relative temperature and humidity in mines examined.*

Name of mine	D.	F.	H.
Date of examination (1916)	June 26	May 5	May 22
Temperature at surface, °F	67½	57	72½
Average temperature underground, °F	73	63	72
Relative humidity at surface	59½	80	19
Average relative humidity underground	97	99	97

Attention is directed to Table 8, which shows the annual rainfall and surface temperature at Jackson, Cal. It will be noted that for 1915 the average temperature on the surface is 59.4° F.; the lowest is 45.4° F. and the highest is 76.4° F. The variable conditions on the surface are a contributing factor in the lower percentage of hookworm infection among the surface workers.

TABLE 8.—*Mean temperature and precipitation at Jackson, Cal.*[a]

Month (1915).	Mean temperature, °F.	Precipitation (inches).	Month (1915).	Mean temperature, °F.	Precipitation (inches).
January	45.4	7.53	August	76.4	0
February	46.5	7.63	September	67.8	0
March	55.0	1.24	October	64.0	0
April	57.0	2.27	November	53.4	1.03
May	58.4	0.93	December	46.2	7.06
June	68.0	0	Annual	59.4	27.69
July	74.9	0			

[a] Readings were taken at Kennedy mine at Jackson, Cal. Results from annual climatological data, California section, Weather Bureau, U. S. Dept. Agriculture.

RELATIVE INFECTIOUSNESS OF THE VARIOUS MINES EXAMINED.

The percentage of infection found among the underground employees does not necessarily measure the relative extensiveness of the infection in the mines. Attention is called to this difference; the mines are infected with hookworm eggs; the miners are infected with hookworms. These will be differentiated hereafter by referring to the infection among the miners and the infectiousness of the mines.

The length of time that the men have worked in the mines perhaps influences the percentage of infection found. It is natural to believe that the likelihood of contracting hookworm infection depends upon the period that the men have been exposed to infectious places. No doubt some of the miners having hookworm contracted their infection in a different mine from the one in which they were working at the time they were examined, but as this would apply to all the mines these cases would perhaps be balanced in attempting to measure the relative infectiousness of the various mines examined.

If all the mines were equally infectious, other factors being the same, there should be a relation between the percentage of infection found and the average duration of employment. The mine with the highest percentage of men infected should have the longest average duration of employment. Table 9 shows this not to be so. Mine C, with the highest percentage of infection, had the second lowest period of employment. This indicates that the extent of infectiousness in the different mines varies.

To take into consideration this time element in estimating the relative infectiousness of the mines, it might be assumed that if at mine A 60 per cent of the men were infected in 48 months, 100 per cent would be infected in 80 months, and that in mine B, if 16 per cent were infected in 26 months, 100 per cent would be infected in 162 months. Comparing 162 with 80, it might be said that mine A is twice as infectious as mine B. This is not actually so, but it is believed to be nearer the truth than if, on comparing 60 per cent with 16 per cent, it was said that mine A was 3.8 times as infectious as mine B.

Table 9 shows the percentage of infection, average duration of employment, estimated time required for 100 per cent infection, order of mines based on the percentage of miners infected, and the order based on the infectiousness of the mine, for the various mines examined. In comparing these two ratings, it will be observed that mine A which is second worst according to the first method becomes sixth worst according to the second method. Mine E which is eighth according to the first method becomes third according to the second. The other mines occupy about the same relative standing with both methods.

TABLE 9.—*Percentage of men infected with hookworm and duration of employment in mines examined.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Percentage of underground men found infected	60	16	67	39	23	21	33	31
Average duration of employment, months	48	26	13	13	8	19	23	17
Estimated time required for 100 per cent infection, months	80	162	19	33	35	91	70	55
Order based upon percentage of infected men	2	8	1	3	6	7	4	5
Order based upon estimated time required for 100 per cent infection	6	8	1	2	3	7	5	4

IMPERMANENCY OF LABOR IN THE MOTHER LODE MINES.

Hookworm infection no doubt is prevalent in other mining States as well as California. The desirability of extending this work into other mining States became apparent at the very outset of this investigation. The labor on the Mother Lode is in a constant state of flux. Numbers of miners were examined and found infected with hookworm, but before treatment could be administered they were gone. Their whereabouts is not known, but in whatever mines they work they will spread hookworm infection if the mine is insanitary and the conditions are "favorable" to the development of hookworm eggs.

Statistics which show the impermanency of labor in the Mother Lode mines are presented in Table 10. The average duration of employment of the underground men at each mine was determined. The date of employment of each man was looked up and the number of months that he had been employed was calculated. These figures were averaged in order to find the average duration of employment of the underground force at each mine. Anyone whose work at any time took him into the mine was classified as an underground man. The longest average period of employment was 48 months, at mine A; the shortest period was eight months, at mine E.

In addition to this the average number employed during 1915 and the average number "paid off" each month during the year 1915 were found for some mines. In mine D there were more than three "turnovers" of the labor force during 1915. At mine C 360 men were paid off during 1915; the proportion of infected men at this mine was 67 per cent. If this rate is applied to the men paid off, about 241 men infected with hookworm left this one mine during the year 1915.

TABLE 10.—*Data showing impermanency of labor in mines of the Mother Lode district.*

Name of mine	A.	B.	C.	D.	E.	F.	G.	H.
Average duration of employment, months	48	26	13	13	8	19	23	17
Average number employed underground in 1915	136	270	259	62	57	.....	120	100
Average number paid off each month during 1915	.....	15	30	.....	16	.....	33	24
Frequency of turnover of labor force in 1915	.....	18	8.6	.....	3.6	.....	3.6	4.2
Average service of Americans, months	61	35	23	17	9	15	23	61
Average service of Italians, months	47	23	4	13	8	19	25	13
Average service of Spaniards, months	.....	18	7	.....	.....	.....	15	13
Average service of Austrians, months	41	32	18	10	7	22	24	11
Percentage of underground employees married	40	.....	.....	.....	35	.....	.....	51
Average service of married employees, months	55	.....	.....	.....	10	.....	.....	27
Average service of unmarried employees, months	40	.....	.....	.....	7	.....	.....	10

The lack of permanent mine labor has other serious aspects in addition to its effect upon hookworm conditions. Floating labor is not efficient labor. The newcomer must get acquainted with the working conditions, and in so doing he wastes not only his own time, but the time of his partner, the shift boss, and the bookkeeper.

Floating labor means uncertain labor. Often the mine is not operated to capacity because of lack of men, and when working places here and there are unoccupied, part of the investment is idle, whereas the overhead expenses are about the same.

Floating labor increases the risk of accidents with the consequent delay, suffering, and disorganization. An output of a mine may be visibly affected for many hours by a fatal accident, every miner being more or less affected by the knowledge of the catastrophe. The greatest cause of mine accidents is falls of rock, and it is logical to think that the miner, having a knowledge of the rock, its stratification, and peculiarities, can guard himself better against such accidents than a new man who is not familiar with his working place. Also loyalty, the most intangible but most valuable of all assets, can not be stimulated in floating labor. This perhaps is its most objectionable feature.

SUGGESTED REMEDIES.

It is believed that the labor supply is a serious problem in this district and must soon be faced earnestly by the mine operators, as by the operators in many other mining districts in the United States. Although the writer does not presume to offer a solution, it is felt that if this problem is studied with the same attention and zeal as are other mining problems, remedies will soon be forthcoming. For example, in some mines of the district the average duration of employment is 48 months, whereas at others the men leave in eight months. A recognition of the losses due to floating labor will be the first step toward its abatement.

A few suggested remedies are given here. More information about the men should be obtained at the time of their employment. Application cards showing the name, nationality, age, marital state, dependents, previous mining experience, etc., of the applicant are now being used at some of the mines and they should be used at all of the mines. Such a system in itself tends to keep away undesirable laborers who come only with the intention of earning a few dollars and then roaming on. When a man is "paid off" a definite reason should be assigned for leaving; if he is discharged, the shift boss should report the reason; if he quits voluntarily, his reason for doing so should be ascertained if possible. Facts thus obtained might be suggestive of remedies. At least it would place the employment question on a more systematic basis.

There appears, as is natural, a seasonal fluctuation; the men quit the mines during the summer to go to ranches, or into the lumbering camps, or into the hop fields, or fruit orchards. Instead of this two months' respite being concentrated into the summer, would it not be better to spread it over the entire year by making every Sunday a holiday throughout the district, only the presence of men absolutely needed being permitted in the mines? If a miner "goes down into the hole" seven days a week, week in and week out, it will not be long before he gets discontented and craves a change. Certain progressive superintendents in the district hold these views and are trying to eliminate Sunday work. The effectiveness of the weekly holiday would work out better if the district unanimously adopted the plan. In some of the coal-mining districts fluctuating employment due to seasonal trade variations is one of the reasons why coal miners roam about. This does not apply to the metal mines of the Mother Lode district, as the mines can be worked throughout the year. Gold sells at a fixed price and many of the mines are uniform producers.

Living and social conditions in the towns adjacent to the mines exert an influence on the problem of labor supply. The two mines adjacent to what might be considered the best town enjoy the steadiest workers. The town conditions are a difficult situation to remedy, as it is the policy of many of the companies not to interest themselves in town affairs or to attempt to regulate the actions of the men when away from the mines. The relative advantages and disadvantages of the company-controlled mining town are too complex to discuss in this paper. Many of the good features of the company town could be adopted with advantage, it is believed. Some of the mine superintendents encourage interest in outdoor sports, such as baseball, by donations and liberal concessions in the working hours of the players.

One of the mining companies recently presented a clubhouse to the town near-by for the benefit of the citizens in general, which included the miners.

A few of the companies exert more or less influence over the boarding and living houses maintained for unmarried miners, and a searching investigation into conditions at bunk houses might be productive of beneficial results.

The possibility of starting a building and loan association of some kind and assisting the men to build homes is suggested by the fact that this method is being tried by operators in other districts. That married men with families make steadier workmen than single men is well known. This statement is confirmed by the results shown in Table 10.

Schools exert an important influence. Special night classes might be formed for young men where practical subjects could be discussed which would help to make them better miners. English-speaking classes for foreigners could be organized. The school system of the Mother Lode district at the time of this investigation appeared to be insufficiently correlated with the basic industry of the district; it lacked localization. Closer interrelation between the school system and the mining industry could no doubt be worked out to the advantage of both and of the community at large.

These few comments on the impermanency of mine labor are offered merely as suggestions and not as a solution of this complicated problem. If they are of any value whatever they will have fulfilled their purpose.

INFECTIOUSNESS OF DIFFERENT OCCUPATIONS IN MINE.

With the hope of learning which particular areas of the mine were infected, or if certain areas were more infected than others, the underground working force was divided into four classes according to the nature of their duties, and the percentage of infection among each class was determined. The four classes were: (1) The bosses and repair men who travel all over the mine; (2) the skip tenders whose domain is the shaft; (3) the miners who spend most of their time in the stopes; and (4) the muckers and car men who traverse the levels.

The value of the results of this study is seriously affected by the changeability of duties, the muckers of one day becoming miners the next, and the miners becoming repair men or bosses. The study is of value as showing indications rather than absolute proofs.

The percentage of infection among the four classes of labor for each mine and the average duration of employment is shown in Table 11.

TABLE 11.—*Results showing percentage of employees infected with hookworm for different classes of labor, and duration of employment.*

Kind of labor.	Number of men examined.	Per cent infected.	Average duration of employment, months.	Kind of labor.	Number of men examined.	Per cent infected.	Average duration of employment, months.
Mine A:				Mine E:			
Bosses and repair men.	28	68	76	Bosses and repair men.	9	22	7
Skip tenders	6	83	91	Skip tenders	2	0	9
Miners	84	55	39	Miners	13	15	9
Muckers and car men	40	38	29	Muckers and car men	32	28	7
Mine B:				Mine F:			
Bosses and repair men.	8	13	99	Bosses and repair men.	5	20	22
Skip tenders	3	67	65	Skip tenders	1	100	77
Miners	201	17	28	Miners	10	20	16
Muckers and car men	80	14	14	Muckers and car men	13	15	16
Mine C:				Mine G:			
Bosses and repair men.	33	70	19	Bosses and repair men.	31	45	46
Skip tenders	2	100	38	Skip tenders	1	100	20
Miners	59	63	19	Miners	22	23	21
Muckers and car men	76	34	6	Muckers and car men	67	30	13
Mine D:				Mine H:			
Bosses and repair men.	10	60	25	Bosses and repair men.	16	31	20
Skip tenders	2	50	12	Skip tenders	2	50	34
Miners	27	40	14	Miners	19	16	17
Muckers and car men	17	24	12	Muckers and car men	47	36	8

It will be noted that the skip tenders and the bosses and repair men show a higher percentage of infection than the miners and the muckers and car men.

No doubt this is partly due to the fact that the skip tenders and the bosses and repair men have been in the mines for a longer period, and the possibility of contact with the disease has been correspondingly greater. At the same time the nature of their duties, traveling about as they do all over the mine, also makes the possibility for contact greater.

The high percentage of infection among skip tenders indicates that the shafts are very infectious. This is what might be expected, as all the mine water drains toward the shaft.

One would expect the car men to be more subject to infection than the miners, because they travel back and forth on the wet levels all day, whereas the miners remain in the comparatively dry stopes. The figures in Table 11 appear to contradict this statement because in five of the eight mines the miners have a higher rate of infection than the muckers and car men. It should be kept in mind, however, that the miners may have worked as muckers or car men before they became miners, and they might have contracted the infection then. It should be noted that in three mines, although the duration of employment of the muckers is shorter than the miners, the rate of infection among the muckers is higher.

PROPORTION OF INFECTION AMONG DIFFERENT NATIONALITIES.

The percentage of infection among the different nationalities for the separate mines and for all the mines combined and the average duration of employment are shown in Table 12.

TABLE 12.—*Results showing percentage of employees infected with hookworm and duration of employment, by nationalities.*

Nationality.	Number of men examined.	Per cent infected.	Average duration of employment, months.
Mine A:			
American	26	50	61
Italian	14	21	47
Austrian	110	54	44
Mine B:			
American	63	17	35
Italian	165	12	23
Spaniard	34	18	18
Austrian	25	44	32
Mine C:			
American	17	35	23
Italian	18	44	4
Spaniard	61	36	7
Austrian	75	70	18
Mine D:			
American	12	42	17
Italian	29	41	13
Austrian	16	31	10
Mine E:			
American	19	21	9
Italian	20	20	8
Austrian	16	31	7
Mine F:			
American	7	14	15
Italian	8	13	19
Austrian	12	33	22
Mine G:			
American	17	12	23
Italian	57	35	25
Spaniard	19	53	15
Austrian	27	37	24
Mine H:			
American	7	....	61
Italian	39	26	13
Spaniard	32	44	13
Austrian	7	29	11
Combined mines:			
American	168	25	33
Italian	350	22	20
Spaniard	148	37	12
Austrian	288	52	29

In combining the results from all the mines it will be noted that the Italians were least infected, the Americans second, the Spaniards third, and that the Austrians had the highest percentage of infection. In four of the eight mines examined the Italians were the lowest; in five of the eight mines the Austrians were the highest; and in four of the mines the Italians had a lower percentage of infection than the Austrians, although the average period of employment in the mine was longer than that of the Austrians. It would appear that this difference between Italians and Austrians is more than a mere coincidence, but a satisfactory explanation can not be given. It may be that the Italians look after their shoes better; it may be a question of personal hygiene; or it may be a dietary difference of the two nationalities.

GENERAL DISCUSSION OF RESULTS OBTAINED.

Referring again to Table 1, it will be noted that the percentage of infected men in the different mines varies from 16 to 67 per cent. It is not an easy matter to account for this difference, as the factors influencing hookworm infection are many and varied. To simplify the explanation only two mines will be compared, the one having the highest and the one having the lowest percentage. Strange as it may appear, there is a striking similarity between these two mines. Offhand one would say that these two mines where hookworm infection is most divergent are more alike than any other two mines examined. Salient facts regarding these two mines are assembled in Table 13.

TABLE 13.—*Data on the two mines having the maximum and minimum percentages of infection.*

	Mine B.	Mine C.
Percentage of underground men infected	16	67
Average number employed underground	270	260
Portable toilet cans underground	Yes.	Yes.
Number of months cans had been installed at time of inspection.	3	6
Number of times per week cans are cleaned	2	7
Depth of lowest level along slope, feet	3,750	2,850
Total number of levels developed		16
Number of active working levels	13	6
Average temperature, ° F	78	75
Average duration of employment of underground men, months.	26	13
Gallons of water removed daily	125,000	200,000
Drainage well taken care of	Yes.	No.
Average relative humidity, per cent	97	99
Approximate slope of shaft	90°	70°
Underground men by nationalities:		
Austrians, per cent	9	44
Italians, per cent	57	11
Spaniards, per cent	12	36
Americans, per cent	22	10

The mines practically adjoin each other, and are the two largest examined, one employing 270 men and the other 260. The present sanitary accommodations in both mines are the same and underground toilet cans have been installed in both for about the same period. They are both deep mines, and there is little difference in temperature, only 3° F.

Some of the conditions indicate that mine B should have a higher percentage of infection than mine C, because the workings are more concentrated, the mine has been worked longer, and has a greater number of total levels and active working levels. Moreover, the average duration of employment of underground men in mine B is 26 months, which is twice that of mine C, and increases the likelihood of infection.

Why, then, are only 16 per cent of the men at mine B infected and 67 per cent at mine C? The following reasons help to explain this discrepancy:

1. Although at present the sanitary accommodations are similar, it is believed that in the past mine B has been kept cleaner than mine C.

2. Mine B makes about 125,000 gallons of water per day, while mine C makes about 200,000 gallons. Mine drainage is carefully watched in mine B, whereas it is not in mine C.

3. Mine C employs a more transient class of labor, therefore the workmen are more indifferent to the welfare of the mine; many men of the floating class apply for work when they are without funds, and go into the mine with wornout shoes and perhaps are negligent about bathing and the cleanliness of their shift clothes. The wash-house at mine C had poorer facilities and was not kept so clean as the one at mine B.

4. Mine B has a vertical shaft, whereas at mine C the shaft is at an angle of about 70°. A vertical shaft is probably easier to keep clean and dry, and subjects the men to less possibility of infection when they are raised and lowered than an inclined shaft. In this connection it is interesting to note that mine B, in addition to its principal vertical shaft, has an inclined shaft a few hundred feet away, which penetrates the older workings. In this old mine 18 men work under conditions approximating those in mine C; 8 of these, or 44 per cent, were infected; whereas only 39 of the 274, or 14 per cent, of the men in the newer part of mine B were infected. This rather confirms the belief that much of the infection is contracted in the shaft.

5. Nationality of labor force is perhaps a factor; of the underground men examined in mine B only 9 per cent were Austrians and 52 per cent were Italians, whereas in mine C 44 per cent were Austrians and 11 per cent were Italians.

Recommendations as to how hookworm infection can be stamped out in the mines of the Mother Lode are contained in pages 43 to 44. This report will place in the hands of mine superintendents of the United States a knowledge of hookworm infection and how it is spread, so that they will be able of their own initiative to eradicate it, if it already exists, or, better still, to install improvements which will prevent its introduction. After all, most of the sanitary recommendations made herein should be followed as a matter of cleanliness and hygiene, irrespective of their relation to hookworm infection.

DIAGNOSIS AND TREATMENT OF HOOKWORM INFECTION.

By James G. Cumming.

As stated in the introduction of this report, it was planned in investigating the prevalence of hookworm infection among the miners of the Mother Lode district, to diagnose fecal specimens from the miners and determine the percentage of infected men.

COLLECTION OF SPECIMENS.

It was decided not to make the microscopical examination of stool specimens in the field, as was the procedure followed by the Rockefeller Foundation, but at the main hygienic laboratory of the bureau of communicable diseases of the California State Board of Health. Consequently it was necessary to devise a convenient container for the collection and transportation of the specimens. The container adopted was a half-ounce wide-mouthed bottle. Into the cork stopper of each bottle there was inserted a galvanized tin spatula somewhat narrower than the mouth of the bottle, which was used to transfer the specimen of stool. The spatula added greatly to the convenience of collecting specimens. The bottles were numbered by first paraffining the exterior, then scratching the number through the paraffin, and finally exposing to hydrofluoric acid. Such a system of marking removes all possibility of error through the accidental removal of a paper label or through the obliteration of an ink number. Five cubic centimeters of a 2 per cent tricresol solution was placed in each container before shipment to the mine superintendent. This solution disinfects the specimen and prevents development of the hookworm eggs.

The containers were shipped to the mine superintendent, who directed their distribution through the mine bosses to the miners with instructions to transfer a specimen of excreta the size of a chestnut to the bottle, then return it to the mine boss. When the containers were returned to the laboratory there was forwarded a list of names of those submitting specimens with their corresponding specimen numbers, also information about miners for use in filling out "hookworm certificates" (see page 41).

DIAGNOSIS OF SPECIMENS.

Although there are various methods of diagnosis of hookworm infection, such as the clinical symptoms, the experimental treatment, the microscopic examination of blood, and the microscopic examination of stool, it was decided that the latter method would best serve the purposes of this investigation.

It was found that there was a great variation in different mines in the percentage of positive specimens, as well as in the degree of infection. It was therefore advisable, as regards economy, to determine whether direct microscopic examination or centrifugalization in conjunction with the microscopic examination was preferable.

THE DIRECT MICROSCOPIC EXAMINATION OF FECES.

By the method of direct examination with the microscope an amount of the specimen about the size of a match head is transferred by a toothpick to a microscopic slide, a separate toothpick being used for each specimen. The specimen is thoroughly suspended in six drops of a 2 per cent tricresol and 2 per cent glycerin solution. Such a suspension is uniform and not too thick. The tricresol acts as a deoderant and the glycerin prevents rapid drying and thus obviates the necessity of a cover glass. To thoroughly examine such a slide requires 20 minutes.

THE DIRECT IMMERSION MICROSCOPIC METHOD.

There are two essential differences between the technique of this and that of the direct method. It was noted by Dr. William Pepper,[a] in 1908, that the eggs of hookworm, although sticking closely to the glass slide, do not adhere to any of the many other constituents of the stool. This sticky property of the hookworm egg, however, is destroyed in the presence of glycerin, so in preparing a specimen for the immersion technique it is necessary to use only tricrescol in the suspending solution. If a suspension of stool is thus prepared in a 2 per cent tricresol solution and is permitted to settle for several minutes and then the slide is gently immersed in slowly running water, the eggs are found adhering to the slide, while the nonadhesive débris is washed away. If several applications of the suspended stool are applied to the slide and gently washed off, the slide becomes thickly studded with eggs. Finally a 2 per cent glycerin solution may be dropped on the slide and the specimen examined under the microscope.

THE CENTRIFUGAL METHOD.

The procedure by the centrifugal method is as follows: An amount of stool about the size of a small lima bean is transferred to a small centrifuge tube, which is about half filled with water. Then the tube is closed by holding a square of thin rubber belting over the opening and the contents are shaken until the material is in homogeneous suspension. Eight such specimens are prepared. After the first centrifugalization of one set of four specimens, in a four-arm centrifuge, the other set of four are centrifuged while the first set is being prepared for the second centrifugalization. In this way no time is lost. After each centrifugalization, the supernatent dirty water containing bacteria and light organic matter is poured off. Fresh water is added, the contents shaken and again centrifuged. It was determined by test that the hookworm eggs were completely thrown down on whirling for 25 seconds at 1,800 revolution per minute. After the third washing the sediment loses its sticky character and is granular in appearance.

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[a] Stiles, C. W., Hookworm disease: U. S. Public Health Service Bull. 32, 1912, 40 pp.

MICROSCOPIC EXAMINATION OF CENTRIFUGED SPECIMEN.

The sediment may be directly examined under the microscope with satisfactory results, for it is found that there is little granular débris to obscure the eggs. Another method is to immerse the sediment before examination. By this procedure the suspended sediment is permitted to stand on the microscopic slide for several minutes, poured off, and the slide gently immersed in slowly running water. If the application, sedimentation, and immersion be repeated several times, the chance of making a positive diagnosis in a lightly infected individual is greatly increased.

It will be noted that the centrifugal and immersion methods here referred to are in the main those originated by Dr. William Pepper in 1908.

In preparing the microscopic slide for examination, the specimen should cover at least the middle two-thirds of the slide, one-third on each side of the center line of the slide. A line of asphalt or one made by a glass pencil will keep the suspended specimen within the desired bounds. The specimen is examined under a one-third inch objective. A mechanical stage is essential, so that the entire specimen may be gone over.

For the purposes of the present investigation of hookworm among miners the method of immersion and microscopic examination of the centrifuged specimen has been adopted as the standard procedure. This method is not only the most reliable, but it has the added advantage of being the most economical in the examination of lightly infected specimens.

If, however, 10 specimens from a lot of 100 or more from any certain mine are examined and 50 or more per cent give a positive test by the direct-immersion method, it is more economical to examine the entire lot by this method first and make use of the immersion method of examining the centrifuged specimen in all those giving a negative test by the direct method.

RESULTS OF EXAMINATION.

The results of the examination of 1,440 specimens are shown in Table 14.

TABLE 14.—*Results of preliminary examination of feces for hookworm, July 5, 1916.*

Mine from which specimens were obtained.	Total number of specimens.	Number giving positive test.	Number giving negative test.	Percentage of positive tests.
A	364	130	234	36
B	307	51	256	17
C	340	139	201	41
D	66	26	40	39
E	56	13	43	23
F	48	8	40	16.6
G	149	46	103	31
H	110	31	79	28
Grand total	1,440	444	996	30.8

ARRANGEMENT AS TO DIVISION OF COSTS AND METHOD AND RESULTS OF TREATMENT.

The mine operators of most of the mines examined have agreed to share with the miner the expense of his treatment. That is, the operator pays the druggist for the medicine and the miner pays the physician, but as at some of the mines the physician is a part of the mine organization, the employee receives the entire treatment, including medicine and physician's attendance, without extra cost.

As there is a division of responsibility for hookworm infection, the miner being partly responsible because of his carelessness and the operator because of the insanitary conditions prevailing in most of the mines, it was considered fair that there should be a division of the cost of treatment, thus impressing upon each the fact that his responsibility should be an influential factor in the success of the campaign against hookworm. Furthermore, it was agreed with the superintendent at each mine that all employees found to be infected must take the treatment, and that specimens from all new employees would be submitted.

The following formula for hookworm treatment was adapted from the United States Public Health Service:

As a preparatory treatment, at 7 a. m. give 60 c. c. and at 7 p. m. 90 c. c. of a saturated solution of sodium sulphate. The next day give 15 drops of oil of chenopodium at 7 a. m., 15 drops at 9 a. m., and 15 drops at 11 a. m. Oil of chenopodium may be given either on a lump of sugar or in a capsule. If in a capsule each dose should be accompanied by 15 drops of HCl in a glass of water.

At 1 p. m. give 20 c. c. of a mixture containing 18 c. c. of castor oil and 2 c. c. of chloroform. At 1.30 p. m. give 30 c. c. of plain castor oil and a cup of hot tea.

The above treatment is for adults. The size of dose for oil of chenopodium is as follows: Children 6 to 7 years old, 5 drops; 8 to 9 years, 7 drops; 10 to 11 years, 10 drops; 12 to 15 years, 12 drops; 16 years and over, and under 60 years, 15 drops. The stock solution of chloroform and castor oil contains 18 c. c. of castor oil and 2 c. c. of chloroform, making 20 c. c. in all, in each dose. For children this mixture is given with plain castor oil as follows: Children 6 to 7 years old, 11 drops or 6 c. c. of the mixture with 14 c. c. of plain castor oil; 8 to 9 years old, 12 drops or 8 c. c. with 12 c. c. of castor oil; 10 to 11 years old, 15 drops or 12 c. c. with 8 c. c. of castor oil; 12 to 13 years, 20 drops or 4 c. c. with 6 c. c. of castor oil; 14 to 15 years, 25 drops or 16 c. c. with 4 c. c. of castor oil; to adults over 15 years and under 60 years give 30 drops or 20 c. c. of the mixture.

The names of the infected men at each mine were sent to the local physician, and arrangements were made so the physician could give the men, in groups of 10, instructions as to the procedure of treatment. It was suggested to the druggists that the distribution of the medicine could be expedited by inclosing the complete treatment in one package with definite labels indicating the order of taking. The cost of one complete treatment is 50 cents, and this is paid by the mine operator.

REEXAMINATION OF SPECIMENS FROM TREATED MEN.

When the treatment of all infected men at any mine is completed the physicians send a list of these, and specimens of stool of these are again submitted for examination.

The results of the reexamination are reported both to the superintendent and the physician. Those miners infected are again treated and specimens submitted for examination.

RESULTS FROM CHENOPODIUM TREATMENT.

Following the first curative treatment, 101 stool specimens have been examined. Of this number of persons 86 (85 per cent) have been cured. Eleven of the remaining 15 were given a second treatment with the result that 5 (45 per cent) were cured. Although the number of cases here reported is not large, yet the value of the chenopodium treatment as compared with the thymol is evident. In the final report on the hookworm investigation the California State Board of Health will make a complete report on the results of the chenopodium treatment.

CERTIFICATE ISSUED TO MINERS FREE OF HOOKWORM.

As soon as a specimen submitted by a miner is found free from infection a certificate is issued to him. On the completion of the examination of the specimens from a mine the certificates are issued to all men whose feces are found negative, and as soon as the infected men are found to be cured, as determined by reexamination, they also receive certificates. The immediate issuance of certificates when the specimens are found free from infection arouses interest sufficient to make those not possessing certificates desirous of getting them. The superintendents of all the mines so far examined have agreed to employ as workers in the mine only those men possessing certificates and, further, to insist that all new employees not possessing certificates submit a specimen for examination and, if necessary, be treated.

It is expected that each superintendent will enforce these regulations and that eventually all California miners will possess a certificate. The cards on which the certificates are printed are 4 inches wide by 2½ inches high. Each certificate bears the following inscription:

Form for hookworm certificate.

CALIFORNIA STATE BOARD OF HEALTH.

BUREAU OF COMMUNICABLE DISEASES.

HOOKWORM CERTIFICATE.

BERKELEY, CALIFORNIA.
Date, ______________.

This is to certify that the excreta of ____________ have been examined microscopically and have been found free from hookworm infection.

____________________,
Director.

Identification.
Age, ______. Height, ______. Weight, ______.
Signature, ____________________.

This certificate is good for one year from date.

(On reverse side.)

HOW TO PREVENT HOOKWORM INFECTION.

1. Never commit a nuisance in the mine.
2. Use surface toilets if possible.
3. Scrub hands thoroughly before eating lunch.
4. Scrub hands thoroughly and take a hot shower at quitting time
5. Boil out shift clothes at least twice a week.
6. Keep your mine shoes in good repair.

Very truly yours,

JAS. G. CUMMING, M. D.,
Director Bureau of Communicable Diseases.
JOSEPH H. WHITE.

It will be noted that the certificate is good for one year from date. This period was chosen because it is expected that after the certificates are issued men will become infected before the mines are entirely freed from hookworm contamination. Moreover, there is a possibility that some of the lightly infected specimens were not recognized on the first examination. In view of these considerations it is the intention of the State board of health eventually to reexamine all California miners.

COSTS OF INVESTIGATION.

The costs of the field examination, collection, and inspection of fecal specimens, and of administering hookworm treatment to 444 miners at 8 mines, are as follows:

Costs of hookworm investigations at 8 mines for 444 miners.

Expenses incurred by the State board of health:		
Traveling expenses		$75.00
Salary for time of field investigation		130.00
500 containers		7.20
Laboratory salaries		132.50
Literature (including "Special Hookworm Bulletin," report cards, and certificates)		53.21
Total		397.96
Examination of specimens:[a]		
Examining 1,119 negative specimens		145.47
Examining 444 positive specimens	$97.68	
Expenses incurred by the mine operators:		
Druggists' bill (444 routine treatments, at approximately 50 cents each)	222.00	
Expenses incurred by the miners:[b]		
Physicians' fees (444 routine treatments, at approximately 50 cents each)	222.00	
Total (exclusive of negative specimens)		541.68
Total expenses (including examination of negative specimens)		687.15

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[a] The total 1,563 specimens were examined at a cost of $0.22 per specimen; the cost of the 1,119 negative specimens was $0.13 per man.

[b] Expense per infected miner, $1.22.

RECOMMENDATIONS FOR THE PREVENTION OF HOOKWORM INFECTION.

By James G. Cumming and Joseph H. White.

In order that the infected mine workers of the Mother Lode be cured, that future infection of the mines be stopped, and that the danger of contracting infection from the existing infectious areas of the mines be minimized, the following 12 recommendations are made to the mine operators of the Mother Lode:

1. Every employee should be examined for hookworm infection. The California State Board of Health will supply specimen bottles and make the examination free of charge.

2. Every infected miner should be treated until cured. The California State Board of Health will reexamine all men to determine whether the treatment has been effective.

3. No applicant for work should be employed until he presents a "hookworm certificate" from the California State Board of Health stating that he is free from hookworm infection. Every miner when found free from hookworm will be issued a certificate. The California State Board of Health will examine specimens of feces from applicants free of charge. The applicant may be employed tentatively while the result of his examination is pending.

4. All mine workmen should be reexamined about one year from the date of the issuance of the "hookworm certificate." It is advisable for the bosses, repair men, and skip tenders to be reexamined six months after date of issuance. The California State Board of Health will make these second examinations free of charge.

5. The toilet accommodations in the mines should be improved by providing toilet cans similar to those shown in figures 1 and 2 (pp. 13 and 14), and these cans should be emptied and cleaned at least three times a week.

6. Sanitary water-flush closets should be installed at the surface convenient to the shaft collar and be maintained in a clean, sanitary condition, and drastic measures should be adopted to prevent defiling of these conveniences.

7. At underground stations where the workmen eat dinner facilities for washing the hands should be installed, benches allowing $2\frac{1}{2}$ feet for each man provided, garbage cans for food remnants

installed and their use enforced, and the stations well lighted and maintained in a clean, sanitary condition.

8. Rats should be exterminated from the mines. It is believed that if the mines are kept as clean as possible the rats will soon be starved out.

9. Sanitary drinking fountains or sanitary water kegs should be used in the mines. If kegs are used, they should be sterilized with live steam each night without fail.

10. The drainage system in the mines should be carefully watched, the mine water being prevented as far as possible from draining from one level to the next. The drainage ditches on the level should be kept open, thus keeping the levels, and particularly the footboards, dry and in good repair and free from muck.

11. Certain improvements should be made on the washhouses. The houses should be scrubbed out with water and a disinfectant after each shift. Additional showers should be installed where necessary, all wash basins discarded, the washing trough made smaller, and the hot and cold water connected to a common mixing pipe, thereby allowing the miner to wash in flowing water of any desired temperature, and facilities provided so that the men may boil their "shift" (working) clothes.

12. The miners should be instructed in the causes, nature, and prevention of hookworm, so that they may know how hookworm is spread and intelligently subscribe to the remedial measures that are introduced. Some educational work has already been achieved by the instructions on the back of the "hookworm certificate," by informal talks given by the field investigators, and by a special circular[a] on hookworm, written by the authors of this report and issued by the California State Board of Health. Arrangements are now under way for holding miners' rallies in important mining centers, where illustrated talks will be given on hookworm infection, its prevention and cure.

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